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WILDLIFE STRIKES TO CIVILIAN AIRCRAFT IN THE UNITED STATES 1993-1995

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COVER:

Two engines from an Air France Concord SST that were destroyed when they ingested Canada geese during touch down at John F. Kennedy International Airport June 3, 1995. The plane suffered damage totaling $7 million. Photo courtesy USDA/APHIS/ADC/NWRC.

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Wildlife Strikes to Civilian Aircraft in the United Sates 1993-1995.

ABSTRACT

This report represents the first analysis of several years of data on wildlife strikes to civilian aircraft in the United States. Reported wildlife strikes involving civilian aircraft in the U. S. for 1993-1995 were analyzed. About 2,200 wildlife strikes were reported to the Federal Aviation Administration (FAA) each year. This reporting rate is probably less than 20% of the actual number. Reports were received from all 50 States and some U.S. territories. About 97% of the reported strikes involved birds, 3% involved mammals, and <1% involved reptiles. Gulls (14%) and waterfowl (6%) were the most commonly struck birds; deer (2%) and coyotes (<1%) were the most commonly struck mammals.

The types of aircraft most frequently involved in wildlife strikes were Boeing 737 (18%), McDonald Douglas MD-80/DC-9 (18%), and Boeing 727 (7%). Aircraft components most frequently damaged by birds were engines (29%), wings (21%), radomes (15%), and windshields (9%). Aircraft components most commonly damaged by mammals were landing gear (23%), propellers (14%), wings (11%), and fuselages (9%).

Twenty-one percent of the bird strike reports, and 76% of the mammal strike reports, stated the strike had a negative effect on the flight: aborted take-off (3%), engine shut down (1%), precautionary landing (5%), other (14%). More bird and mammal strikes occurred per unit of time during dusk than at any other time of day, 164 strikes/hour and 5.3 strikes/hour respectively. Most bird strikes occurred during the day (66%), in late summer and early fall (51%), when the aircraft was on approach (37%), or during take-off (33%). Ninety percent occurred under 2,300 feet above ground level (AGL). Most mammal strikes occurred at night (68%), during the fall and early winter (57%).

For the 3-year period, 15% (979) of the bird strikes and 40% (71) of the mammal strikes caused damage to the aircraft. An additional 427 reports (6%) indicated the strike had some negative effect on the flight, such as a precautionary landing or aborted take-off. Of the 1,050 strike reports indicating aircraft damage, only 530 reports provided an estimate of the aircraft down time (265 reports totaling 67,000 hours, avg. = 253 hours/report) and/or monetary losses (265 reports totaling $27.6 million, avg. = $104,000/report). We suggest these figures severely underestimate the actual cost of wildlife strikes to the civilian aviation industry because only 25% of the reports indicating aircraft damage provided an estimate of the aircraft down time and/or monetary loss, and we estimate <20% of all strikes are reported. The actual losses attributable to wildlife strikes are likely closer to 374,000 hours/year of aircraft down time and $153 million/year in direct aircraft damage and related monetary losses.

Traditionally, airport wildlife management programs have focused on gulls because they have been the species most commonly involved in wildlife strikes. The data indicate that while it is important not to lose sight of the role gulls play in wildlife strikes, the emphasis needs to be expanded to include other birds (especially waterfowl, raptors, and wading birds), as well as deer.

INTRODUCTION

Wildlife strikes have been occurring almost since the beginning of powered flight. Calbraith Rodgers, the first man to fly across the United States, was also the first to die as a result of a bird-aircraft collision. On April 3, 1912, Rodgers' Wright Pusher struck a gull, causing the aircraft to crash into the surf at Long Beach, California. As a result of several major aircraft accidents resulting from bird-aircraft collisions (Civil Aeronautics Board 1962, National Transportation Safety Board 1973, National Transportation Safety Board 1975, and others), the Federal Aviation Administration (FAA) began systematically collecting bird aircraft strike data in the late 1970's using FAA Form 5200-7 - *Bird Strike Incident/Ingestion Report*. In 1989, FAA Form 5200-7 was modified to include strikes by other wildlife such as deer and coyotes. The extent of the wildlife-aircraft strike problem has been largely unquantified in the United States due to a lack of data analyses. Although the FAA monitored the reports in an effort to determine general trends, no detailed analyses were undertaken.

In April 1995, through an interagency agreement between the FAA and the U. S. Department of Agriculture's National Wildlife Research Center (NWRC), a project was initiated to obtain more objective and continuous estimates of the magnitude and nature of the wildlife strike problem to civilian aircraft in the U.S. The interagency agreement calls for NWRC to: 1) edit all strike reports (Form 5200-7) received by FAA to ensure consistent, error-free data, 2) enter all edited strike reports into the FAA Wildlife Strike Database, 3) supplement FAA-reported strikes with additional, non-duplicating strike reports from other sources, 4) provide FAA with an updated computer file each quarter containing all edited strike records, and 5) produce annual reports summarizing the results of the analyses. Such analyses are critical to determine the economic costs of wildlife strikes, the magnitude of safety issues, and most importantly, the nature of the problems (e.g., bird species, aircraft and engine types, airports, seasonality) so that corrective actions can be taken. In November 1995, NWRC submitted the first annual report *Bird and other wildlife strikes to civilian aircraft in the United States, 1994*, to the FAA (Dolbeer et al., 1995). This second report presented here includes the 1994 data summarized by Dolbeer et al. (1995) in a more comprehensive analysis of the FAA Wildlife Strike Database, covering 1993-1995. Subsequent annual and multi-year reports will follow.

Important factors to consider in reading this report are that completion of FAA Form 5200-7 is voluntary and many aircraft strikes go unreported. Dolbeer et al. (1995) calculated that in 1994, only 12% of the wildlife strikes occurring at John F. Kennedy International Airport (JFK) were entered into the FAA Wildlife Strike Database. Assuming this to be typical

for the aviation industry in general, the strike data presented here represents <20% of the actual total.

METHODS

When a wildlife-aircraft strike occurs, someone (most often the pilot) voluntarily completes FAA Form 5200-7 and mails it to the FAA. All reports received are examined by the FAA staff wildlife biologist. Copies of major incident reports (Title 14, Code of Federal Regulations, Part 139.337, a:1-2) are forwarded to the appropriate U. S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control (ADC) State Director, and FAA Regional Lead Certification Inspector. A print-out from the FAA Wildlife Strike Database showing the strike history for the airport in question is also provided.

The ADC State Director can contact the airport and offer assistance, or the FAA Certification Inspector can request that ADC contact the airport operator, or the airport operator can contact ADC and request assistance. A Memorandum of Understanding (MOU) exists between FAA and ADC for assistance with wildlife hazard problems on airports. Generally, there is no charge to an airport for basic wildlife hazard evaluations conducted by ADC. It is only when long-term ecological studies are undertaken that cost becomes an issue.

All FAA Form 5200-7s are forwarded to NWRC's Sandusky, Ohio Field Office for entry into the FAA Wildlife Strike Database. After computer entry, all forms are archived by the date of the strike. Quarterly, NWRC supplies FAA's Office of Airport Safety and Standards with updates of the strike database by computer disk. Selected information in the FAA Wildlife Strike Database is made available to interested parties upon request.

Methods used to sort, screen, edit, enter data, and archive the report forms are discussed in Dolbeer et al. (1995) and Wright (1996). Unless specifically stated, the numbers and percentages presented in the results represent the totals, and average values for the 1993-1995 period. All percentages are based on the total known number. No attempt has been made to distinguish among years in the narrative, unless there was a major difference in the numbers. The numbers for individual years, 3-year averages, and the percentages of the total known are presented in most tables.

RESULTS

In 1993-1995, 6,697 non-duplicate reports of wildlife strikes (6,522 with birds, 175 with other wildlife) were received and entered in the database; 82% came from FAA Form 5200-7. Six percent of the reports received came from multiple sources (Table 1). The majority of the reports (75%) came from commercial carriers, 11% from the business sector, and 7% from the private sector. In 7% of the cases, the type of aircraft operator was not reported (Table 2).

Reports were received from all 50 states, Puerto Rico, and the U.S. Virgin Islands. California (10.3%), Texas (8.0%), Florida (7.5%), Illinois (6.6%), New York (5.6%), and Pennsylvania (5.1%) reported the most bird strikes. Pennsylvania (11.5%), Illinois (10.9%), Texas (7.5%), New York (6.3%), Michigan (5.7%), and New Jersey (5.7%) reported the most mammal strikes. Reported strikes to American-owned aircraft occurring outside of the U.S. totaled 135 bird strikes and 3 mammal strikes (Table 3).

About half (3,287) of the reported bird strikes occurred during July (11%), August (13%), September (14%), and October (13%). Twenty-two percent of the reported bird strikes occurred during March-May. The majority (53%) of reported deer strikes occurred in September (13%), October (15%), and November (19%) (Table 4, Figures 1 & 2).

Only 183 (3%) of the reported bird strikes and 13 (8%) of the reported mammal strikes did not report the time of occurrence. Of those reports where the time of day of the strike was reported, 4,160 (66%) of the bird strikes, occurred during the day, and 1,551 (24%) occurred at night. This contrasted with 38 (24%) of the reported mammal strikes occurring during the day and 109 (69%) at night (Table 5, Figures 3 & 4).

Most (6,137, 94%) bird strike reports indicated the phase of flight when the strike occurred: 36% during approach, 18% while landing, <1% when taxiing, 32% during take-off, and 6% during climb-out. Ninety percent (158) of the mammal strikes reported the phase of flight when the strike occurred: 9% of the mammal strikes occurred when the plane was airborne - striking bats. The remainder occurred when the plane was landing (57%) or during take-off (34%) (Table 6).

The altitude above ground level (AGL) of the strike was indicated in 83% (5,404) of the reports. Thirty-eight percent of the known altitude strikes were reported as occurring when the aircraft was on the ground, 16% occurred between 1 and 100 ft AGL, 75% occurred under 600 feet AGL, 90% occurred under 2,300 ft AGL, 95% occurred under 4,100 ft AGL,

and over 99% of the known altitude strikes occurred under 9,000 ft AGL. The highest altitude AGL for a reported strike was 25,000 feet (Table 7, Figure 5).

Short-haul commercial aircraft reported the greatest number of wildlife strikes : Boeing 737 (1,207, 18%), McDonald Douglas MD-80/DC-9 (1,183, 18%), Boeing 727 (473, 7%). The remaining aircraft types reported <4% each. The types of aircraft reporting the most strikes also reported high numbers of strikes having an effect on the flight or causing damaging to the aircraft (Table 8).

Aircraft components most commonly reported as being struck by birds were windshields (1,177), engines (840), noses (835), wings/rotors (816), radomes (667), and fuselages (660). Those components suffering the greatest percentage of damage when struck by birds were lights (89%), tails (43%), engines (40%), wings/rotors (37%), Radomes (13%), and landing gear (11%). Mammals were most often struck by the landing gear (60%) and were much more likely to be involved in a damaging strike than were birds (Table 9). Forty percent of the mammal strikes and 15% of the bird strikes damaged the aircraft.

About 22% of the reported bird strikes indicated the strike affected the flight: 5% prompted a precautionary landing, 3% resulted in an aborted take-off, 1% caused the engine to shut down, and 13% had some other effect. Six percent did not report the effect, if any, and 72% had no reported effect. About 64% of the mammal strikes affected the flight: 8% resulted in a precautionary landing, 12% caused an aborted take-off, and 44% had some other effect. Fourteen percent did not report the effect, if any, and 24% reported no effect (Table 10).

Birds were involved in 6,522 (97%) reported strikes, mammals in 173 (3%), and reptiles in 2 (<1%). The bird or bird group involved was identified in 48% of the reports. The mammal or mammal group, and reptile or reptile group involved was identified in all cases. Gulls (30%), waterfowl (12%), doves (10%), raptors (10%) and sparrows (8%) were the most commonly struck birds (Table 11 A). Deer (66%), coyotes (14%), and bats (5%) were the most commonly struck mammals (Table 11 B).

Sixteen percent (979 bird and 71 mammal) of the reports indicated that the strike damaged the aircraft. Additionally, 427 reports, although not reporting damage, indicated the strike had some effect on the flight (e.g. delay or aborted takeoff). However, only 265 reports (25% of the 1,050 reports indicating damage; 18% of the 1,507 reports reporting damage or effect on flight) provided an estimate of the aircraft down time (totaling

67,000 hours, avg. = 253 hours) and only 256 (25%) provided an estimate of monetary losses (totaling $27.6 million, avg. = $104,000). The number of reported damaging strikes was similar for gulls (167, 16%) and waterfowl (171, 16%). Geese were involved in 109 of the 171 reported damaging waterfowl aircraft strikes. Deer were involved in 66 (6%) of the damaging strikes (Table 12).

The total reported bird strike damage amounted to 30,000 hours of aircraft down time and over $26 million of aircraft damage and related cost. Waterfowl, primarily geese, caused the majority ($12 million, 47%) of the monetary losses followed by raptors ($2.7 million, 8%), wading birds and doves ($1.5 million, 5%, each), gulls ($1.2 million, 4%), and deer ($0.5 million, 2%). Reported mammal strike damage totaled 37,000 hours of aircraft down time and over $700,000 of aircraft damage and related losses (Table 13). Deer caused the majority (29,000 hours, 44%), of aircraft down time followed by gulls (10,000 hours, 15%), waterfowl (8,000 hours, 10%), and coyotes (6,000 hours, 9%). We believe these figures significantly under represent the actual losses because of low reporting rates and other factors. The actual figures are probably closer to 374,000 hours/year of aircraft down time and $153 million/year monetary losses (see discussion).

DISCUSSION

This report is the first multi-year examination of wildlife strike data for U. S. civilian aircraft. The report lays a foundation for further analyses as additional data become available.

No airports or aircraft types are immune from the hazards of a wildlife-aircraft strike. However, with over 90% of strikes occurring below 2,300 feet AGL, short-haul commercial aircraft are especially vulnerable. Boeing 727, 737, 757, McDonald Douglas MD-80/DC-9, and Fokker

FK-100 aircraft were involved in over 50% of the reported strikes during 1993-1995. Compared to long-haul aircraft, these aircraft types spend more time operating at lower altitudes. Airport wildlife management programs aimed at reducing wildlife strikes must focus not only on eliminating wildlife attractants on and in the vicinity of airports, but they also need to address hazardous wildlife movements in the vicinity of the airport’s approach/departure airspace and aircraft movement areas.

Most bird strikes occurred during the day (66%) and most mammal strikes occurred at night (68%) . However, more bird and mammal strikes occurred per unit of time during dusk than at any other time. Given that dawn and dusk are 0.75 hours each and day and night average 11.25 hours

each, the bird strike rate/hour for the four periods was: dawn, 115 strikes/hour; day, 123 strikes/hour; dusk, 164 strikes/hour; and night, 46 strikes/hour. The mammal strike rate/hour was: dawn 1.3 strikes/hour; day 1.2 strikes/hour; dusk, 5.3 strikes/hour; night 3.3 strikes/hour.

Seasonally, two peak periods of bird strikes were noted. About half (3,287) of the reported bird-aircraft strikes occurred in July -October, and 22% of the strikes occurred during March - May. The summer-fall period corresponds with the fledging season, when large numbers of young inexperienced birds are present, as well as with the annual fall migration. The spring peak corresponds with spring migration (Bellrose 1980, Johnsgard 1968).

Most mammal (primarily deer) strikes occur at night (66%). Seasonally, the majority (53%) of the reported deer-aircraft strikes occurred in September (13%), October (15%), and November (19%), the time period of most deer-auto accidents (Bellis and Graves 1971). This time period corresponds to the dispersal of the previous years' fawns and the rutting season (Severinghaus and Cheatum, 1969). Pilots and airport personnel responsible for wildlife-aircraft safety should be especially vigilant during these peak periods of wildlife activity.

Gulls were involved in more civilian aircraft strikes (30% of total) than waterfowl (13% of total). However, both were involved in essentially the same number of damaging strikes: gulls (167, 16% of the total), waterfowl (171, 16% of the total). Further, reported waterfowl strike damage ($12.1 million) was over nine times the reported damage caused by gulls ($1.3 million). Of the $12.1 million in damage to civilian aviation caused by waterfowl, geese caused almost $12 million. Seven million dollars of the $12 million aircraft damage caused by geese came from one strike (Ralph Carrozza, FAA Certification Inspector, AEA-620, personal communication). On June 3, 1995 an Air France Concord caught fire after two of its four engines ingested Canada geese during touch down at John F. Kennedy International Airport. Both engines were destroyed and the plane suffered other damage. No passengers were injured.

Two other note-worthy aircraft strikes involving Canada geese occurred in 1995. On September 22, an Air Force Airborne Warning and Control System (AWACS) aircraft crashed, killing all 24 people on board, after ingesting geese into its number 1 and 2 engines during takeoff from Elmendorf Air Force Base, Alaska. This was the first crash of an AWACS plane since the Air Force began using them in 1977 (Bird, 1996). Because this strike involved a military aircraft, it is not included in the FAA Wildlife Strike Database. On September 25, a Cessna Citation, carrying U. S. Representative and House Speaker Newt Gringrich and his party, struck

Canada Geese on takeoff from Mackinac Island, MI. One goose was ingested into the right engine and 1 other struck the leading edge of the left wing. The pilot aborted the takeoff, stopping the plane 30 feet off the end of the runway. There were on injuries. (Washington Post, 9/23/95, p A4) It is not surprising that geese cause more damage than gulls when colliding with aircraft because geese are heavier (8 - 12 pounds versus 1 - 3 pounds respectively) and denser than gulls (Seamans et al. 1995).

Traditionally, airport wildlife management programs have focused on the most frequently struck species of gulls (e.g., McLaren et al. 1984, Dolbeer and Bucknell 1994). Our data indicate that while it is important not to loose sight of the role gulls play in wildlife strikes, the emphasis needs to be expanded to include waterfowl (especially geese), raptors, wading birds and deer. Many species of gulls, urban Canada geese and deer are undergoing marked population increases throughout many areas of the U. S. and Canada (Rusch et al. 1995, Hestbeck 1995, Stont, et al. 1993, Dolbeer and Bernhardt 1986, Blokpoel and Tessier 1986, Conover and Chasko 1985). As populations of these species continue to increase, the strike potential will also increase correspondingly.

The full magnitude of the wildlife-aircraft strike problem is difficult to assess for a number of reasons. First, many of the reports are completed and submitted by personnel who, for various reasons, simply do not know the extent of the damage, the amount of aircraft down time, or monetary loss. FAA has no mechanism for back tracking and retrieving these lost data. Second, we know that most wildlife-aircraft collisions are not reported to the FAA. The reporting rate is affected by such factors as: the safety awareness programs and policies of the airlines involved, the flight or ground personnel's awareness of the strike and their willingness to complete the necessary paperwork, the safety awareness programs and attitude of the airport management and operations personnel and their willingness to complete the necessary paper work, and whether or not there is an active airport wildlife management program that constantly encourages the reporting of wildlife strikes .

Washington Dulles International and Chicago O'Hare have very active wildlife management programs with at least one ADC Wildlife Biologist working full time on these airports. Martin Lowney (State Director ADC, Virginia, personal communication) reported 28 wildlife strikes at Washington Dulles International Airport between 1 September 1994 and 31 August 1995, 17 of which were in the FAA Database, a 60% reporting rate. Robert Sliwinski (Wildlife Biologist, ADC/NWRC, personal communication) calculated that 58% of the strikes occurring at Chicago's O'Hare Airport were entered into the FAA Database. These airports are the exception, rather than the rule. John F. Kennedy International Airport

(JFK) has an excellent bird aircraft strike awareness and control program, and yet only 12% of the known wildlife strikes occurring in 1994 at JFK were in the FAA database (Dolbeer et al. 1995). JFK's reporting rate is probably closer to the national average than are the reporting rates of Washington Dulles International or Chicago O'Hare.

Even though the full magnitude of the wildlife-aircraft strike problem is difficult to assess, it is possible to estimate the probable minimum and maximum cost to U. S. civilian aviation, given the reports received by the FAA are a representative sample of the whole and a 20% reporting rate.

For 1993-1995, there were 1,507 (23%) reports indicating that the strike damaged one or more parts of the aircraft and/or had a negative effect on the flight, i.e. precautionary landing, aborted take-off, fuel dump, etc. However, only 265 (18%) reports provided an estimate of the monetary loss (totaling $27.6 million, avg. = $104,000/report). In addition, only 265 (18%) reports provided an estimate of the amount of time the aircraft was out of service for inspection or repairs as a result of the strike (totaling 67,000 hours, avg. = 253 hours down time/report). The average annual reported losses were $9.2 million and 22,300 hours of aircraft down time.

If we assume that the reported monetary losses and aircraft down time were all of the losses sustained by the 1,507 effected aircraft, and that there was a 20% reporting rate, then the annual cost of wildlife-aircraft collisions to U.S. civilian aviation was no less than $46 million/year in monetary losses and 112,000 hours/year of aircraft down time, 1993-1995.

Or, if we assume the 1,242 strikes that reported aircraft damage or effects on flight but did not report monetary losses or down time also averaged $104,000 in damage and 253 hours down time per strike, then the totals losses for the 3-year period for reported strikes would be $157 million and 381,000 hours of aircraft down time, or $52 million and 127,000 hours down time per year for reported strikes. If only 20% of the strikes were reported each year, then the annual cost of strikes to U.S. civilian aviation would be $260 million/year in monetary losses and 635,000 hours/year of aircraft down time, 1993-1995.

The actual losses to U.S. civilian aviation should fall between these two extremes. Averaging these extremes places the annual cost of wildlife strikes to U. S. civilian aviation at $153 million/year in monetary losses, and 374,000 hours/year of aircraft down time Wong (Larose and MacKinnon 1996) reported that 33% of all foreign object damage (FOD) suffered by United Airlines was caused by birds. Wong reported the cost of all FOD to U. S. civilian aviation at $350 million annually. Given the percentage of bird-caused FOD experienced by United Airlines is typical

for the airline industry as a whole, the annual industry-wide cost of bird damage is $117 million. Both our and Wong's estimate of the cost of wildlife strikes are well over $100 million/year. Conover et al. (1995) estimated wildlife aircraft strikes cost the U.S. military $112 million/year in damages. Thus the cost of wildlife strikes to U. S. civilian and military aviation well exceeds $200 million annually

An indication of the magnitude of the wildlife civilian aircraft strike problem in the U.S. is starting to emerge from the analyses of these data. More detailed analyses involving more years of data need to be analyzed before an accurate picture of the problem and its cost to the civilian aviation industry is assembled. However, we now have enough data to begin making reliable predictions regarding the occurrence of strikes, such as the most likely time of day, time of year, altitude, and wildlife species involved. Persons charged with airport wildlife management can use this data to begin to formulate, justify, and take corrective actions. The accuracy of our analyses and resulting recommendations are limited by data availability. Those within the aviation industry are encouraged to report all wildlife strikes so that we can continue building an accurate picture of the problem. This will enable wildlife managers and the aviation industry to work together to reduce the wildlife strike rate and improve the safety and economics of U. S. civilian and military aviation.

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Table 1. Sources of information for reported wildlife strikes to civilian aircraft, USA, 1993-1995.

	Number reported (% of total)			
	Years			
Source	1993	1994	1995	3-Yr. avg.
FAA form 5200-7	1,795 (81)	1,852 (84)	1,881 (83)	1,843 (82)
FAA Air Carrier Incident Report	106 (5)	79 (4)	80 (4)	88 (4)
Individual Airports	89 (4)	33 (1)	37 (2)	53 (2)
FAA Preliminary Aircraft Incident Report	13 (1)	21 (1)	66 (3)	33 (2)
NASA Aviation Safety Reporting System	7 (<1)	18 (1)	1 (<1)	9 (<1)
FAA Aircraft Accident-Incident Preliminary Notice	18 (1)	8 (<1)	9 (<1)	12 (1)
Other	39 (2)	35 (2)	70 (3)	48 (2)
Multiple sources	134 (6)	167 (7)	136 (6)	146 (6)
TOTAL	2,204	2,213	2,280	2,232
	(100)	(100)	(100)	(100)

Table 2. Number of reported wildlife strikes to civilian aircraft, by type of operator, USA, 1993-1995

	Number reported (% of total)			
	Years			
Operator	1993	1994	1995	3--Yr. avg.
Commercial carrier	1,635 (74)	1,667 (75)	1,729 (76)	1,677 (75)
Business	224 (10)	204 (9)	312 (14)	247 (11)
Private	154 (7)	190 (9)	108 (5)	151 (7)
Government/Police	6 (<1)	9 (<1)	12 (1)	9 (<1)
Unknown	185 (8)	143 (6)	119 (5)	149 (7)
TOTALS	2,204 (100)	2,213 (100)	2,280 (100)	2,232 (100

Table 3 Number and percent of reported bird and mammal strikes to civilian aircraft 1993-1995, by U. S. States, including Puerto Rico (PR) and U.S. Virgin Islands (VI).

	Birds					Mammals				
	Years					Years				
STATE	1993	1994	1995	3-Yr. avg.	% of total	1993	1994	1995	3-Yr. avg.	% of total
AK	10	17	22	16	0.8	0	0	1	<1	0.6
AL	21	60	30	37	1.7	1	0	0	0	0.6
AR	9	14	16	13	0.6	0	2	2	1	2.3
AZ	12	12	15	13	0.6	2	2	1	2	2.9
CA	210	221	239	223	10.3	0	1	2	1	1.7
CO	19	21	14	18	0.8	0	1	2	1	1.7
CT	23	33	29	28	1.3	2	0	2	1	2.3
DC	44	63	54	54	2.5	0	0	1	<1	0.6
DE	1	6	1	3	0.1	0	1	0	<1	0.6
FL	140	167	181	163	7.5	0	1	2	1	1.7
GA	28	66	49	48	2.2	1	1	1	1	1.7
HI	24	17	35	25	1.2	0	0	0	0	0.0
IA	23	20	24	22	1.0	2	0	0	1	1.1
ID	2	5	10	6	0.3	0	0	0	0	0.0
IL	173	124	132	143	6.6	8	3	8	6	10.9
IN	23	18	31	24	1.1	0	2	1	1	1.7
KS	10	8	11	10	0.5	4	0	0	1	1.1
KY	74	66	54	65	3.0	0	0	1	<1	0.6
LA	70	48	71	63	2.9	0	0	0	0	0.0
MA	39	28	29	32	1.5	0	0	0	0	0.0
MD	26	29	31	29	1.3	0	2	4	2	3.4
ME	10	7	17	11	0.5	0	0	1	<1	0.6
MI	53	40	31	41	1.9	1	8	1	3	5.7
MN	25	27	13	22	1.0	0	0	0	0	0.0
MO	43	36	51	43	2.0	1	3	0	1	2.3
MS	14	11	6	10	0.5	0	1	0	<1	0.6
MT	6	2	4	4	0.2	0	0	0	0	0.0
NC	46	74	72	64	2.9	0	4	0	1	2.3
ND	3	8	8	6	0.3	0	0	0	0	0.0
NE	27	33	25	28	1.3	1	0	0	<1	0.6
NH	9	14	6	10	0.4	0	2	1	1	1.7
NJ	75	80	83	79	3.6	3	7	0	3	5.7
NM	3	4	9	5	0.2	0	0	0	0	0.0
NV	2	9	10	7	0.3	0	0	1	<1	0.6
NY	138	108	117	121	5.6	3	4	4	4	6.3
OH	83	78	83	81	3.7	2	0	1	1	1.7
OK	14	11	9	11	0.5	1	1	0	1	1.1
OR	26	21	24	24	1.1	0	0	1	<1	0.6
PA	101	108	122	110	5.1	6	8	6	7	11.5
PR	4	0	2	2	0.1	0	0	0	0	0.0
RI	7	9	6	7	0.3	1	0	0	<1	0.6
SC	12	12	15	13	0.6	2	0	0	1	1.1
SD	2	4	5	4	0.2	0	0	0	0	0.0
TN	62	45	51	53	2.4	0	0	1	<1	0.6
TX	194	180	150	175	8.0	6	2	5	4	7.5
UT	32	24	18	25	1.1	1	0	0	<1	0.6
VA	42	56	54	51	2.3	1	0	4	2	2.9
VI	4	5	8	6	0.3	0	0	0	0	0.0
VT	1	2	2	2	0.1	0	0	0	0	0.0
WA	57	42	44	48	2.2	0	0	1	<1	0.6
WI	21	13	26	20	0.9	1	4	0	2	2.9
WV	11	10	10	10	0.5	2	5	2	3	5.2
WY	1	2	0	1	0.0	1	1	0	1	1.1
TOTALS										
US States & territories	2,109	2,118	2,159	129	97.9	49	66	57	57	98.9

FGN[1]	47	26	62	45	2.1	1	2	0	1	1.7
All reported strikes	2,156	2,144	2,222	2,174	100.0	50	68	57	58	100.0

1. FGN. Foreign strikes. Strikes involving American owned aircraft occurring outside the United States and its territories.

Table 4. Number of reported bird and mammal strikes involving civilian aircraft by month, USA, 1993-1995. See also Figures 1 and 2.

	Years					
Month	1993	1994	1995	Total reported	3-Yr. avg.	% of total
BIRDS						
Jan.	97	89	95	281	94	4
Feb.	93	75	73	241	80	4
Mar.	131	120	153	404	135	6
Apr.	180	145	147	472	157	7
May	195	170	204	569	190	9
Jun.	157	137	141	435	145	7
Jul.	227	227	235	689	230	11
Aug.	287	297	284	868	289	13
Sep.	323	310	275	908	303	14
Oct.	249	265	308	822	274	13
Nov.	123	198	193	514	171	8
Dec.	92	111	113	316	105	5
Totals	2,154	2,144	2,221	6,519	2,173	100
MAMMALS						
Jan.	3	2	2	7	2	4
Feb.	1	2	1	4	1	2
Mar.	1	6	10	17	6	10
Apr.	3	1	3	7	2	4
May	4	3	0	7	2	4
Jun.	8	3	4	15	5	9
Jul.	5	4	3	12	4	7
Aug.	0	3	4	7	2	4
Sep.	7	7	8	22	7	13
Oct.	7	12	7	26	9	15
Nov.	7	17	9	33	11	19
Dec.	4	8	6	18	6	10
Totals	50	68	57	175	58	100

Table 5. Reported time of occurrence (strikes/hour[1]) for wildlife strikes to civilian aircraft, USA, 1993-1995. See also Figures 3 and 4.

	Number of reported strikes							
	Year							
	1993		1994		1995		3-Year average	
Time of strike	Birds	Mammals	Birds	Mammals	Birds	Mammals	Birds	Mammals
Dawn	81	1	71	-	105	1	86 (115)	1 (1.3)
Day	1,373	20	1,392	7	1,395	11	1,387 (123)	13 (1.2)
Dusk	122	2	136	5	110	6	123 (164)	4 (5.3)
Night	512	25	487	53	552	31	517 (46)	37 (3.3)
TOTALS								
Time reported	2,088	48	2,086	64	2,162	49	2,112	54
Time not reported	65	3	58	4	60	8	61	5
Strikes	2,153	51	2,155	68	2,222	57	2,173	59

1. Strikes/hour calculations are based on the assumption that dawn and dusk average 0.75 hours in length and day and night average 11.25 hours in length.

Table 6. Reported phase of flight of wildlife strikes to civilian aircraft, USA, 1993-1995.

	Number of reported strikes							
	Year							
	1993		1994		1995		3-Year average	
Phase of flight	Birds	Mammals	Birds	Mammals	Birds	Mammals	Birds	Mammals
Descent	68	-	68	-	85	-	74	-
Approach	760	9	705	1	752	4	737	5
Landing	344	22	402	39	339	28	365	30
Taxi	9	-	8	-	14		10	-
Take-off	606	12	689	26	679	17	659	18
Climb	137	-	114	-	139	-	130	-
En Route	75	-	71	-	73	-	73	-
Total reported	1,999	43	2,057	66	2,081	49	2,048	53
Not reported	154	8	87	2	141	8	127	6
Total strikes	2,153	51	2,144	68	2,222	57	2,175	59

Table 7. Number of reported bird strikes to civilian aircraft by elevation (feet) above ground level (AGL), USA, 1993-1995. See also figure 5

Altitude (ft AGL) range			Number of strikes: Years 1993	1994	1995	3-Yr. avg.	% of total	Cumulative % of total
0	to	0	622	754	664	680	38	37.8
1	to	100	301	281	302	295	16	54.1
101	to	200	126	141	131	133	7	61.5
201	to	300	94	89	101	95	5	66.7
301	to	400	53	66	64	61	3	70.1
401	to	500	49	28	36	38	2	72.2
501	to	600	59	60	56	58	3	75.5
601	to	700	21	17	17	18	1	76.5
701	to	800	14	15	12	14	1	77.2
801	to	900	19	35	24	26	1	78.7
901	to	1,000	11	4	13	9	1	79.2
1,001	to	1,100	60	61	56	59	3	82.5
1,101	to	1,200	8	6	5	6	<1	82.8
1,201	to	1,300	11	20	18	16	1	83.7
1,301	to	1,400	10	5	5	7	<1	84.1
1,401	to	1,500	8	10	6	8	<1	84.5
1,501	to	1,600	38	32	35	35	2	86.5
1,601	to	1,700	6	7	7	7	<1	86.9
1,701	to	1,800	8	2	7	6	<1	87.2
1,801	to	1,900	9	7	10	9	<1	87.7
1,901	to	2,000	6	4	3	4	<1	87.9
2,001	to	2,100	30	26	38	31	2	89.6
2,101	to	2,200	2	1	3	2	<1	89.7
2,201	to	2,300	4	6	6	5	<1	90.0
2,301	to	2,400	4	1	2	2	<1	90.2
2,401	to	2,500	4	1	1	2	<1	90.3
2,501	to	2,600	16	18	9	14	1	91.1
2,601	to	2,700	2	1	1	1	<1	91.2
2,701	to	2,800	3	1	4	3	<1	91.3
2,801	to	2,900	3	2	5	3	<1	91.5
2,901	to	3,000	1	2	1	1	<1	91.6
3,001	to	3,100	31	24	36	30	2	93.2
3,101	to	3,200	0	0	2	1	<1	93.3
3,201	to	3,300	1	5	0	2	<1	93.4
3,301	to	3,400	2	1	2	2	<1	93.5
3,401	to	3,500	7	1	2	3	<1	93.7
3,501	to	3,600	2	4	12	6	<1	94.0
3,601	to	3,700	0	2	0	1	<1	94.0
3,701	to	3,800	3	2	1	2	<1	94.2
3,801	to	3,900	0	0	1	<1	<1	94.2
3,901	to	4,000	1	0	2	1	<1	94.2
4,001	to	4,100	0	15	30	15	1	95.1
4,101	to	4,200	0	1	0	<1	<1	95.1
4,201	to	4,300	18	1	2	7	<1	95.5
4,301	to	4,400	0	0	2	1	<1	95.5
4,401	to	4,500	2	0	0	1	<1	95.5
4,501	to	4,600	0	5	12	6	<1	95.9
4,601	to	4,700	3	0	0	1	<1	95.9
4,701	to	4,800	2	1	0	1	<1	96.0
4,801	to	4,900	0	0	0	0	<1	96.0
4,901	to	5,000	18	2	0	7	<1	96.3
5,001	to	6,000	29	28	18	25	1	97.7
6,001	to	7,000	9	16	13	13	1	98.4
7,001	to	8,000	7	7	14	9	1	98.9
8,001	to	9,000	6	3	9	6	<1	99.3
9,001	to	10,000	0	6	2	3	<1	99.4
10,000	to	15,000	9	10	10	10	1	100.0
15,001	to	25,000	0	2	1	<1	100.0	
TOTALS								

Altitude reported	1,753	1,837	1,801		100	100.0
Altitude not reported	401	307	372			
All reported strikes	2,154	2,144	2,173			

Table 8. Total number of reported wildlife strikes to civilian aircraft and the number and percentage of strikes reporting an effect on aircraft flight or damaging the aircraft, by aircraft type, 1993-1995

Aircraft manufacture	Aircraft model	No. of reported strikes	No. of Strikes effecting flight	% of strikes effecting flight	No. of strikes damaging aircraft	% of damaging strikes
Boeing	B-737	1,207	275	23	187	15
McDonald Douglas	MD-80/DC-9	1,183	148	26	112	19
Boeing	B-727	473	51	11	37	8
Fokker	FK-100	254	24	9	18	7
Boeing	B-757	250	54	22	42	17
British Aerospace	BA-31	186	66	35	45	24
Saab	340	161	41	25	21	13
Beach	1900	141	45	32	42	30
deHavilland	DHC8 Dash 8	125	21	17	10	8
Embraer	120	123	22	18	11	9
Cessna	172	116	50	43	49	42
Avions Transp. Regional	42	114	21	18	20	18
Cessna	152	104	43	41	28	27
Airbus Industries	A-300	101	17	17	11	11
Boeing	B-747	100	30	30	32	32
Learjet	25	90	28	31	22	24
Boeing	B-767	84	13	15	13	15
McDonald Douglas	C-8	73	6	8	6	8
Shorts	360	63	13	21	10	16
McDonald Douglas	C-10	58	9	16	7	12
Sweringen	3 Merlin	57	18	32	9	16
Fokker	FK-28	51	11	22	9	18
Total		5,114	1,006		741	
All other aircraft		1,583	489		309	
Total all aircraft		6,695	1,495	22	1,050	16

Table 9. Civilian aircraft components reported as being struck and damaged (% damaged) by wildlife, USA, 1993-1995.

	Number of reported strikes							
	Year							
	1993		1994		1995		3-Year average	
Parts of aircraft	Bird	Mammal	Bird	Mammal	Bird	Mammal	Bird	Mammal
Radome								
Struck	200	-	229	2	247	1	225	1
Damaged	25	-	44	43	-	-	37(16%)	1
Windshield								
Struck	364	-	411	1	402	2	392	1
Damaged	25	-	39	1	42	1	35(9%)	1
Nose								
Struck	254	2	277	4	304	3	278	3
Damaged	25	1	19	3	17	2	20(7%)	2
Propeller								
Struck	73	2	88	13	96	10	86	8
Damaged	11	2	7	11	5	6	8 (9%)	6
Wing/rotor								
Struck	243	2	274	11	299	4	272	6
Damaged	85	1	91	11	100	3	92 (37%)	5
Fuselage								
Struck	213	2	231	8	216	6	220	5
Damaged	10	1	9	7	7	4	9 (4%)	4
Landing Gear								
Struck	89	13	124	29	125	18	113	20
Damaged	9	10	15	16	12	12	12(11%)	13
Tail								
Struck	25	-	28	3	37	21	30	8
Damaged	12	-	13	3	15	1	13(43%)	1
Engines								
Struck	250	2	299	6	291	5	280	4
Damaged	112	1	126	4	99	2	113(40%)	2
Lights								
Struck	23	1	17	2	17	-	19	1
Damaged	20	1	15	2	15	-	17(89%)	1

Table 10. Reported effect-on-flight of wildlife strikes to civilian aircraft, USA, 1993-1995.

	Number of reported strikes							
	Year							
	1993		1994		1995		3-Year average	
Effect on flight	Birds	Mammals	Birds	Mammals	Birds	Mammals	Birds	Mammals
None	1,541	12	1,584	15	1,596	15	1,574	14
Aborted take-off	52	3	66	11	58	7	59	7
Engine shut down	8	-	11	-	16	-	12	-
Precautionary landing	116	-	112	5	110	6	113	4
Other	258	25	267	32	311	21	279	26
Not reported	178	9	104	6	131	8	138	8
Total	2,153	51	2,144	68	2,222	57	2,175	59

Table 11 A. Identified bird groups most commonly involved in reported wildlife strikes to civilian aircraft, USA, 1993-1995.

	Number of reported strikes				
	Year				
Wildlife groups	1993	1994	1995	3-Year average	% of total known
Gulls	350	321	295	322	30
Waterfowl	140	146	125	137	13
Ducks	(66)	(66)	(35)	(57)	(5)
Geese/swans	(74)	(80)	(81)	(80)	(7)
Blackbirds	136	132	113	127	12
Blackbirds	(81)	(71)	(69)	(74)	(7)
Starlings	(55)	(61)	(44)	(53)	(5)
Doves	110	135	90	112	10
Rock doves	(40)	(46)	(47)	(44)	(4)
Mourning doves	(70)	(89)	(53)	(71)	(7)
Raptors	103	108	121	111	10
Hawks	(76)	(85)	(99)	(87)	(8)
Owls	(25)	(15)	(18)	(19)	(2)
Eagles	(2)	(8)	(4)	(5)	(<1)
Sparrows	89	90	79	86	8
Corvids	24	35	30	30	3
Crows	(21)	(33)	(29)	(28)	(3)
Ravens	(1)	(2)	(1)	(1)	(<1)
Shorebirds	18	33	25	25	2
Pelicans	(1)	(4)	(3)	(3)	(<1)
Plovers	(1)	(4)	(3)	(3)	(<1)
Killdeer	(12)	(17)	(13)	(14)	(1)
Sandpipers	(4)	(8)	(6)	(6)	(1)
Vultures	13	23	16	17	2
Waders	28	23	28	26	2
Egrets	(18)	(14)	(15)	(16)	(1)
Herons	(7)	(7)	(6)	(7)	(1)
Cranes	(3)	(1)	(6)	(3)	(<1)
Grebes	(-)	(1)	(1)	(1)	(<1)
Swallows	31	25	18	25	2
TOTALS					
Known birds	1,094	1,086	1,017	1,066	100
Unknown birds	1,059	1,058	1,205	1,108	
Reported strikes	2,153	2,144	2,222	2,173	

Table 11 B. Identified mammal and reptile groups most commonly involved in reported wildlife strikes to civilian aircraft, USA, 1993-1995.

	Number of reported strikes				
	Years				
Wildlife Group	1993	1994	1995	3-Year average	% of total known
Ungulates	33	56	32	41	69
Deer	(30)	(55)	(30)	(39)	(66)
Elk	(-)	(1)	(-)	(<1)	(1)
Cattle	(-)	(2)	(1)	(1)	(2)
Pronghorn	(1)		(1)	(1)	(2)
Carnivores	6	12	16	11	19
Coyotes	(4)	(9)	(11)	(8)	(14)
Dog	(-)	(1)	(2)	(1)	(2)
Fox	(-)	(1)	(2)	(1)	(2)
Raccoon	(2)	(1)	(1)	(1)	(2)
Bats	6	-	3	3	5
Opossum	2	-	1	1	2
Woodchucks	4	-	3	2	4
Total reported mammal strikes	51	68	57	58	100
Reptiles	(-)	1	1	1	100
Alligator	(-)	(1)	(-)	(<1)	
Turtle	(-)	(-)	(1)	(<1)	

Table 12. Number of reported wildlife strikes causing damage to civilian aircraft, by wildlife group, USA, 1993-1995.

	Years					
	1993	1994	1995	Total damaging strikes	3-Year average	% of total
BIRDS						
Gulls	53	56	58	167	56	16
Waterfow[1]	48	63	60	171	57	16
Blackbirds	11	9	8	28	9	3
Doves	15	13	12	40	14	4
Raptors[2]	22	27	17	66	28	8
Crows	9	5	-	14	7	2
Vultures	7	13	10	30	10	3
Waders[3]	7	5	5	17	7	2
Misc. birds	3	7	7	17	6	2
Unknown birds	134	133	162	429	143	41
TOTAL BIRDS	300	335	344	979	326	93
MAMMALS						
Ungulates[4]	12	36	20	68	23	7
Carnivores	-	2	1	3	1	<1
TOTAL MAMMALS	12	38	21	71	24	7
Grand total	312	373	365	1,050	350	100

1. Geese caused 109 of the 171 damaging waterfowl strikes
2. Hawks caused 50 of the 66 damaging raptor strikes.
3. Herons caused 11 of the 17 damaging wading bird strikes.
4. Deer caused 66 of the 68 damaging ungulate strikes.

Table 13. Reported losses (aircraft down time in hours, repair cost, lost revenue, and other monetary losses) resulting from wildlife strikes to civilian aircraft, USA, 1993-1995.

	Losses -- time and money							
	Years							
	1993		1994		1995		3-Year totals	
	Hours	Dollars	Hours	Dollars	Hours	Dollars	Hours	Dollars
BIRDS								
Gulls	7,864	$134,762	574	$727,440	1,347	$418,604	9,785	$1,280,806
Waterfowl[1]	2,504	$63,400	2,479	$1,408,924	2,990	$10,591,471	7,973	$12,063,795
Blackbirds	83	$7,900	769	$463,000	6	$11,000	858	$481,900
Doves[2]	12	$75,100	24	$400	39	$1,507,290	75	$1,582,790
Raptors[3]	181	$382,500	3,868	$2,164,500	235	$214,763	4,284	$2,761,763
Shorebirds	6	$6,000	97	$55,500	-	-	103	$61,500
Vultures	524	$50,000	153	$11,148	35	$55,000	712	$116,148
Waders[4]	1,387	$65,000	125	$507,000	97	$1,003,000	1,609	$1,575,000
Unknown birds	2,397	$4,872,254	788	$956,456	1,408	$1,080,005	4,593	$6,908,715
Total losses birds strikes	14,960	$5,656,916	8,952	$6,301,828	6,165	$12,882,183	30,077	$26,840,927
MAMMALS								
Ungulates[5]	3,600	$132,000	25,668	$463,342	80	$35,500	29,348	$630,842
Carnivores[6]	-	-	5,760	$105,000	2,160	$35,500	7,920	$140,500
Total losses mammals strikes	3,600	$132,000	31,428	$568,342	2,240	$71,00	37,268	$771,342
Total losses all strikes	18,560	$5,788,916	40,380	$6,870,170	8,405	$12,953,183	67,345	$27,612,269

1. Geese caused $11.98 million of the $12.06 million in waterfowl-caused damage.
2. One rock dove strike caused $1.50 million of the $1.58 million in dove-caused damage.
3. Hawks caused $2.30 million of the 2.76 million in raptor-caused damage.
4. Herons caused $1.50 of the $1.57 million in wading bird-caused damage.
5. Deer caused $500,000 of the $600,000 in ungulate-caused damage.
6. Coyotes caused $105,000 of the $140,000 carnivore-caused damage.

Bird Aircraft Strikes

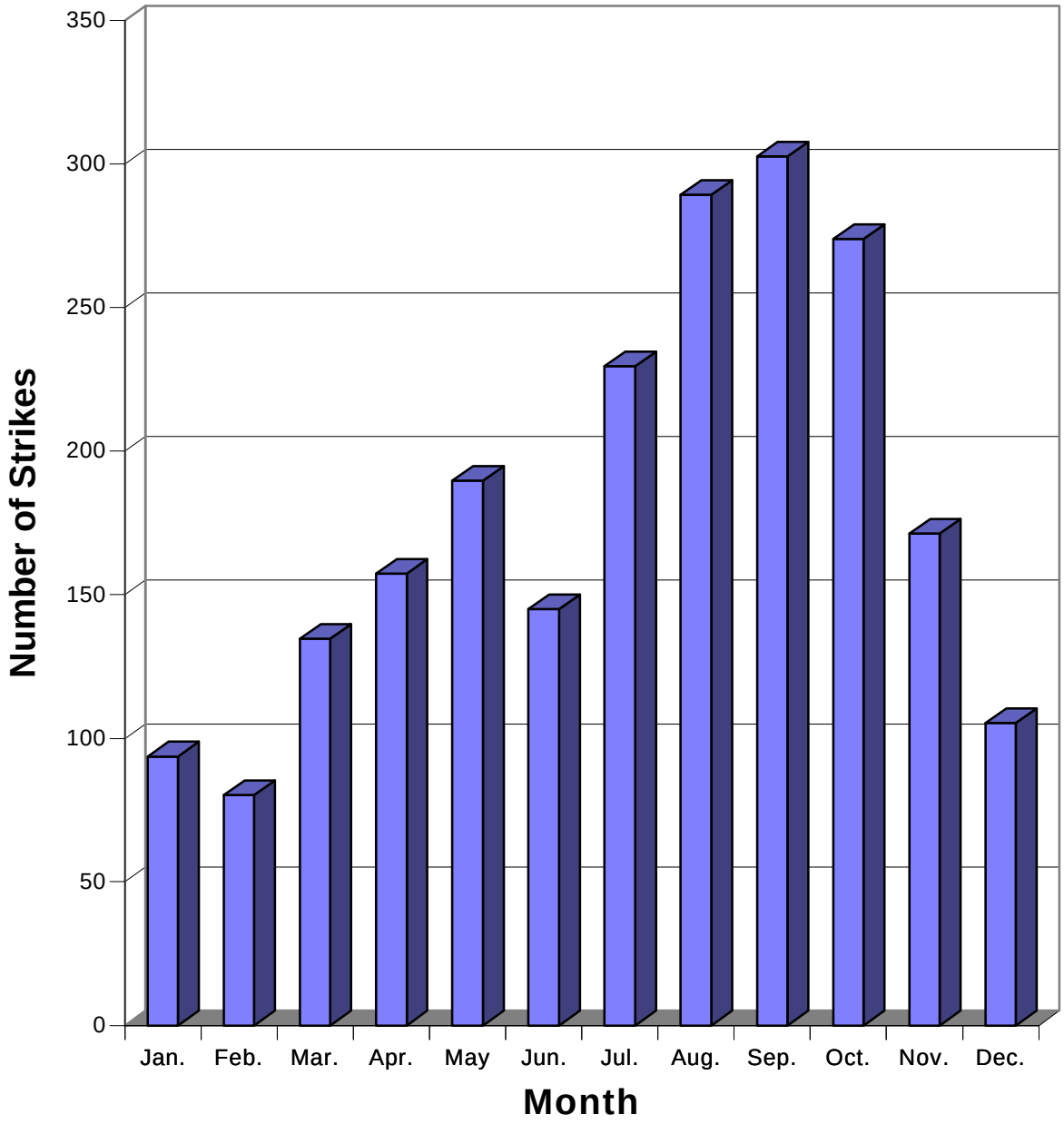

Figure 1. Mean number of reported bird strikes involving civilian aircraft, USA, 1993-1995. See also table 4

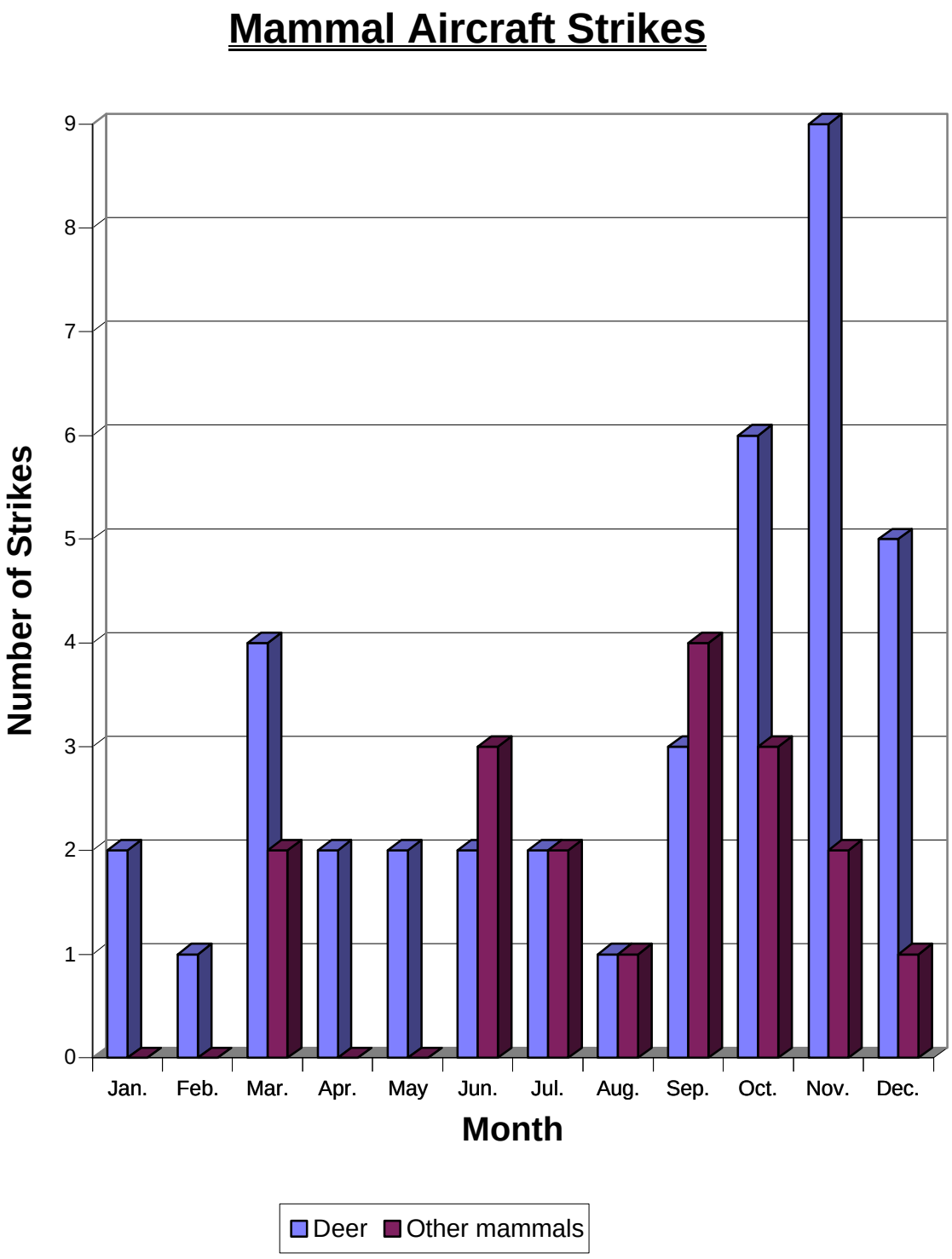

Figure 2. Mean number of reported mammal strikes involving civilian aircraft by month, USA, 1993-1995. See also table 4.

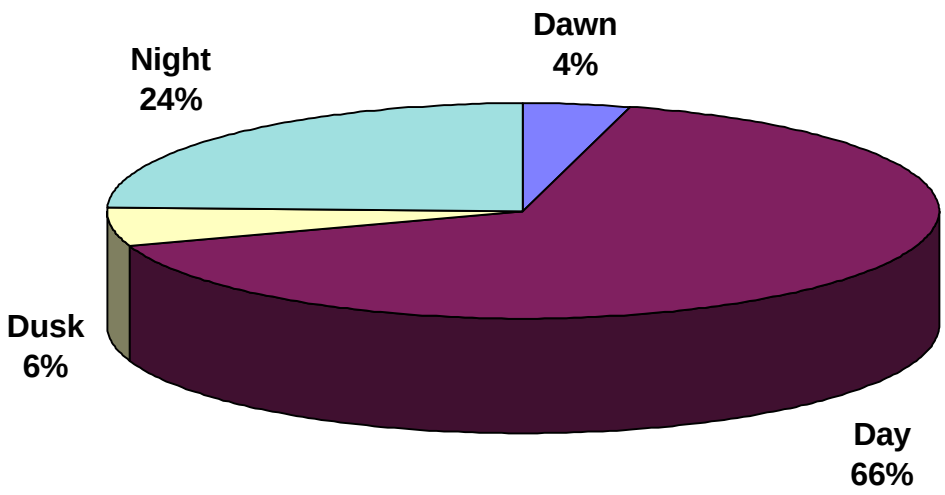

Figure 3. Time of occurrence of reported bird strikes involving civilian aircraft, USA, 1993-1995. See also Table 5.

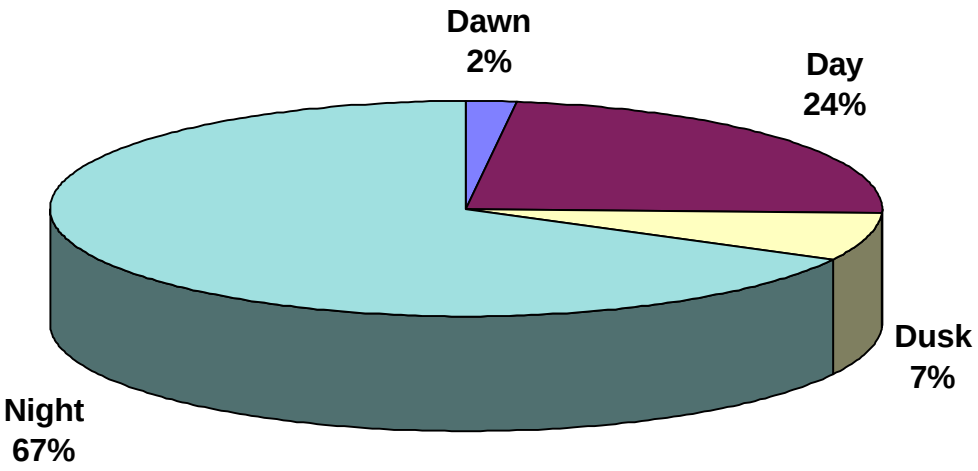

Figure 4. Time of occurrence of reported mammal strikes involving civilian aircraft, USA, 1993-1995. See also Table 5

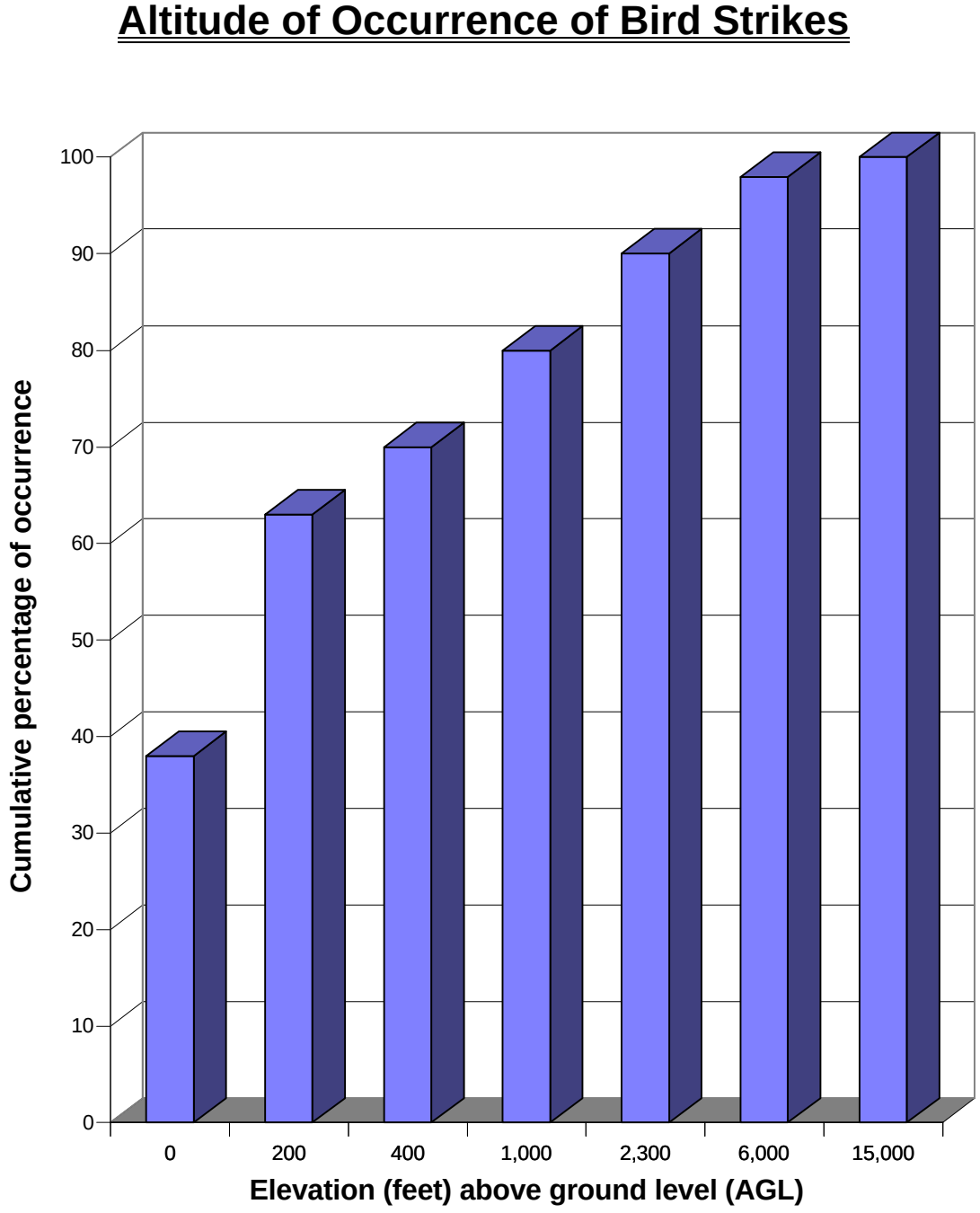

Figure 5. Cumulative percentage of reported bird strikes involving civilian aircraft by altitude (feet) above ground level (AGL), USA, 1993-1995. See also Table 7.